

*Sadovskiy, V.D.*

USSR/Solid State Physics - Mechanical Properties of Crystals  
and Polycrystalline Compounds.

E-10

Abs Jour : Referat Zhur - Fizika, No 5, 1957, 11938

Author : Smirnov, L.V., Sadovskiy, V.D.

Inst : -

Title : Investigation of the Reversible Temper Brittleness of  
Structural Alloyed Steels.

Orig Pub : Probl. metalloved. i term. obrabotok, Moskova - Sverdlovsk,  
Mashgiz, 1956, 120-140

Abstract : A study was made of the influence of the effect of the fol-  
lowing factors on the development of reversible temper  
brittleness: prolonged high temper, preliminary reheating,  
and plastic deformation in the austenitic state. An expla-  
nation is proposed fro the obtained results, and there  
practical significance is indicated, particularly with res-  
pect to possible methods for improving the structure of  
overheated steel. Bibliography, 8 titles.

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SAROVSKIY, V. D.  
✓ The Effect of Cold Reduction on Reversible and Irreversible  
Temper Brittleness, M. M. Shteynberg, V. D. Sedovskiy and  
A. V. Demekova, *Metallurgiya i Otkovka Stal', 1956,*  
7 June 26, 1956, 51, 9 98%, 51, 9 97%

S.A. DOUSKIY, V.D.

USSR / Phase Conversions in Solids.

E-5

Abs Jour : Ref Zhur - Fizika, No 4, 1957, No 9308

Author : Shteynberg, M.M., Sadovskiy, V.D., Demakova, A.V.

Inst : Ural' Polytechnic Institute USSR

Title : Investigation of the Irreversible Temper Brittleness of Alloyed Ferrite.

Orig Pub : Metallovedeniye i obrabotka metallo, 1956, 1956, No 4, 21-25

Abstract : Alloyed ferrite with a carbon content of 0.010 -- 0.020% is analogous with respect to the amount of alloying elements to structural alloyed steels (1.5% chromium and 3.5% nickel; 1% chromium, 1.5% manganese and 1.5% silicon), being susceptible to irreversible temper brittleness, which manifests itself in the same range of temper temperatures as for structural steels. The susceptibility to irreversible brittleness is observed also in that case, when the carbon in the steel is bound in titanium carbides and the steel loses

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USSR / Phase Conversions in Solids.

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Abs Jour : Ref Zhur = Fizika, No 4, 1957, No 9308

Abstract : its hardening ability. This indicates that the irreversible temper brittleness can be observed not only in the absence of residual austenite, but also in the absence of the martensitic phase in that sense, which is used with respect to the carbon-containing alloys.

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SECRET, U.S.D.

USSR / Mechanical Properties of Crystals and Polycrystalline  
Compounds.

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Abs Jour : Ref Zhur - Fizika, No 4, 1957, No 9463

Author : Shteynberg, M.M., Sadovskiy, V.D., Demakova, A.V.

Inst : Ural' Polytechnic Institute USSR

Title : Influence of Cold Plastic Deformation on the Irreversible  
and Reversible Temper Brittleness.

Orig Pub : Metallovedeniye i obrabotka metallov, 1956, No 6, 26-35

Abstract : The brittleness that develops upon tempering hardened chrome-nickel iron (0.02% C, 1.45% Cr, and 4.06% Ni) in the interval from 300 to 350° (irreversible temper hardness) is annihilated by the action of plastic deformation, which increases considerably the impact viscosity of alloyed ferrite, worked into the state of irreversible temper brittleness. The plastic deformation, carried out by rolling at room temperature, also increases substantially the impact visco-

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USSR / Mechanical Properties of Crystals and Polycrystalline  
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Abs Jour : Ref Zhur - Fizika, No 4, 1957, No 9463

Abstract : sity of structural alloyed steel (steels of the 30 KhGSA type were studied), worked into a state of reversible temper brittleness. The character and intensity of the influence of cold plastic deformation on the impact viscosity depend on the structural state of the alloy. The deformation increases the impact viscosity of the alloys, worked into a brittle state, and reduces or changes very little the impact viscosity of alloys worked into a viscous state. The similarity between the phenomena of irreversible temper brittleness and the deformation aging is emphasized and arguments are stated in favor of recognizing the generality of the nature of reversible and irreversible temper brittleness as phenomena that are due to the decay of the supersaturated  $\alpha$ -solution.

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Methods for refining the grain of alloyed cast steel by a thermal treatment. V. D. Sadovskiy, K. A. Malvaev, and B. G. Sazonov. *Tруды Inst. Fiz. Metal. Akad. Nauk S.S.S.R., Ural. Filial* 1956, No. 17, 8-19. Cooling large austenitic grains of cast hypoeutectoid steel may lead to the pptn. of excess ferrite at the boundaries and within the grain, the orientation of which follows that of the original austenite grain. Pearlite, as a rule, is formed as individual colonies, the orientation of which is independent from that of the original austenitic grain. With an increasing undercooling, the no. of pearlitic colonies inside of each primary crystal increases, and their orienting power with respect to the original grain and among themselves decreases. When it is sufficient to suppress ferrite pptn., the austenite decomp. with the formation of a pseudo-eutectoid ferrite-carbide mixt. of laminary character. The no. and size of these colonies in each primary grain, as well as their orientation, are defined by undercooling. At this point the structure loses completely its original coarseness, and further reheating above the  $A_1$  point for quenching or normalizing cannot induce grain coarsening, as shown by fracture. With a still higher cooling rate or an increased alloy content the pearlitic transformation is suppressed and is replaced with the martensite formation which is definitely oriented with respect to austenite leading to coarse fractures. While each vol. corresponding to an austenitic grain breaks, in this case, into a multitude of  $\alpha$ -phase crystals, the latter are united into groups, characterized by a common orientation which can be called intragranular texture and which persists in transformations. The product of such transformation in each primary grain is polycryst. and mono-

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cryst. at the same time. With a moderate cooling rate each austenitic grain is broken into a no. of primary areas, the individuality of grains of the original structure is lost to a great extent, and the fracture appearance is detil. by the size of pearlitic colonies. On cooling, an acicular structure of the decompn. products results and the situation is basically changed. Crystallographically oriented transformation mechanism induces an intracryst. texture uniting  $\alpha$ -crystallites of the original grain into a single pseudo-cryst. complex, a pseudograin, which inherits the size, shape, and, to some extent, the orientation of the primary grain. Coarse fracture of cast steel depends on the creation and retention above the crit. point of the secondary intragranular structure, i.e., crystallographic orientation of the primary austenitic grains persisting in spite of allotropic transformations above the  $A_1$ - $A_2$  points. Its elimination is connected with the recrystn. of the already formed austenite well above the  $A_1$ - $A_2$  points, i.e., around 1000-1100°, caused by internal stresses in the new austenitic grains produced by volumetric changes of the  $\alpha$ - $\gamma$  transformation. Their formation depends, with the same compn. and original structure, on the rate of heating. Samples of C 0.4, Cr 1.5, Si 1.5% steel oil quenched from 1300°, reheated to 920°, and either furnace cooled or oil quenched showed a coarsely cryst. fracture when the heating rate to 920° was 300°/sec. or 3-3°/min., and very fine fracture when the heating rate of 150-200°/min. was employed, fracturing being done at -196°. The new scheme

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of recrystn. is reduced to the existence of a new crit. point, that of austenite recrystn. caused by internal stresses, more accurately of a certain temp. interval located in the austenitic field of constitutional diagrams; and, therefore, unconnected with allotropic changes. This point, which corresponds to a full recrystn. of steel, appears to be identical with the  $\delta$  point of Chernov proposed before the establishing of the  $A_1$  and  $A_2$  crit. temps. (cf. *Science of Metals, metallurg. izdat.*, 1935).

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SADOVSKIY, V.D.

Effect of preliminary overheating of steel on the kinetics of super-cooled austenite dissociation. Trudy Inst. fiz. met. no.17:41-66 '56.  
(Steel--Heat treatment) (Austenite) (MIRA 10:4)

SOV/137-57-10-20073

Translation from: Referativnyy zhurnal, Metallurgiya, 1957, Nr 10, p 233 (USSR)

AUTHORS: Smirnov, L.V., Sadovskiy, V.D.

TITLE: The Structural Mechanism of Transformations During the Heating of Steel (K voprosy o strukturnom mekhanizme prevrashcheniy pri nagreve stali)

PERIODICAL: Tr. In-ta fiz. metallov. Ural'skiy fil. AN SSSR, 1956, Nr 17, pp 94-110

ABSTRACT: An examination is made of the structural mechanism of the formation of austenite in the heating of steel. The possibility of nondiffusive transformation of martensite into austenite with heating, by suppression of the diffusive processes of decomposition (through raising the rate of heating, or by alloying), in a fashion similar to the supercooling of austenite to the martensite point on cooling, is qualitatively proved. Gradient heating followed by structure study is used on specimens of 37KhNZA steel to investigate austenite formation. It is shown that austenite formation may proceed either by a diffusive

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reaction of ferrite and carbides or by an intermediate process with partial precipitation of the C from the martensite, in which case the residual a solution of the alloying elements undergoes a "nondiffusive" ordering transformation, or by a truly nondiffusive reversible martensitic transformation. Various transformation mechanisms may come into play, depending upon the conditions of heating.

A. Z.

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SOV/137-57-10-20216

Translation from: Referativnyy zhurnal, Metallurgiya, 1957, Nr 10, p 258 (USSR)

AUTHORS: Sadovskiy, V.D., Malyshev, K.A.

TITLE: Fractures in Structural Steel (Izlomy konstruktsionnoy stali)

PERIODICAL: Tr. In-ta fiz. metallov. Ural'skiy fil. AN SSSR, 1956, Nr 17,  
pp 111-118

ABSTRACT: An examination is made of the possibilities and limitations of the method of studying the structure of steel by the appearance of fractures (F). It is shown that while the standard metallographic analysis does not detect differences in structure due to temper brittleness, the appearance of a F changes sharply when this phenomenon is present from the normal fibrous to intergranular. The change in the appearance of the F is related to the fact that indistinguishable structural changes induce sharp shifts in the cold-shortness threshold. A brittle intergranular F reveals the grain size of austenite prior to the cooling of the steel. This proposition holds for cases in which the F crack proceeds along the grain boundaries (GB) of the (initial) austenite, where there are heterophasic impurities that weaken the GB concentrate (and, sometimes, microscopic cracks, such as in steel

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### Fractures in Structural Steel

overheated in hardening). It also holds for steels quenched to martensite or to martensite or to intermediate austenite decomposition products. F does not expose the GB in cases of viscous failure (fibrous fracture), in a steel containing pearlite, if the crack passes along the grains or the GB of the pearlitic component, in cases of precipitation of nonmetallic inclusions along the GB during prior operations (casting, rolling, or forging) or if there is a crystallographically ordered structure due to prior high heating. An examination is made of types of F arising in structural steel under various conditions of heat treatment. Ways and means of eliminating naphthalin F (transcrystalline F through the austenite grain) are examined. An examination is made of types of lithoidal cleavage fracture (completely or partially intercrystalline F along the GB of austenite, existing at the moment of overheating) and of methods of eliminating them. Technical recommendations are made on evaluating structure in accordance with the appearance of the F and methods of correcting it.

L.M.

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SOV/137-57-10-20095

Translation from: Referativnyy zhurnal, Metallurgiya, 1957, Nr 10, p 236 (USSR)

AUTHORS: Bogacheva, G.N., Sadovskiy, V.D.

TITLE: Recrystallization in the Heating of Eutectoid Aluminum Bronze (Perekristallizatsiya pri nagreve evtektoidnoy alyuminiyevoy bronzy)

PERIODICAL: Tr. In-ta fiz. metallov. Ural'skiy fil. AN SSSR, 1956, Nr 17, pp 125-138

ABSTRACT: Specimens of Al bronze (12.11% Al) are used to study the structural mechanism of recrystallization upon heating. The kinetics of the  $\beta' \rightarrow \beta$  transformation upon heating are studied by dilatometry. Samples prehardened to martensite being employed. Comparatively rapid heating (200-300°C/min) does not result in recrystallization, and the grain reveals high stability. Phase transformation setting in at 420°, according to the dilatometric curves, proceeds within the existing grains, and the recrystallization process is not accompanied by recrystallization of solid  $\beta$  solution owing to internal work-hardening during

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Recrystallization in the Heating of Eutectoid Aluminum Bronze

the reverse martensite transformation. However, slow heating of quenched bronze to above the critical point ( $750^{\circ}$ ) results in intensive grain growth in the  $\beta$  phase. This growth may also be induced in fast heating if the specimens are first tempered at  $450-500^{\circ}$ . Thus it is shown that the tendency to grain growth is acquired as the result of structural transformations in solid  $\beta$  solution at  $450-500^{\circ}$  only.

A.Z.

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SOKOLKOV, E. N. SADOVSKIĬ, V. D.

ness) was present in all the steels tested. Cr, W, and Mo shifted the min. to higher temps., to 300-400° as compared with 250-300° of C steel; this shift was increased by 4 and 8% Ni. No correlation was found between the curves of  $\sigma_1$  vs.  $I$  and those of  $\Delta I$  vs.  $I$ . In most specimens the decompn. of residual austenite occurred after the min.; in  $\sigma_1$  was passed. On the other hand, a definite relation between this min. and  $\Delta H$  was established: in all cases the min.  $\sigma_1$  corresponded to the point of carbide formation. In steels 38KhN8B and 38KhN8M the decrease in  $\sigma_1$  was slight, whereas  $\Delta H$  passed through a well-defined max. The lack of a sharp decrease in  $\sigma_1$  was attributed to the abundance of fine crystals in these alloys. These and earlier available data pointed to the conclusion that carbide formation rather than the decompn. of the residual austenite (cf. Grossman, C.A. 40: 3379) was the detg. factor in the development of irreversible temper brittleness. This conclusion was further supported by studies of micrograms and by the following expts.: to decrease the austenite decompn. to a min. the effect of the duration of tempering was detd. on pieces of 38KhN4C tempered at 400° and of 38KhN8CB tempered at 420° for 5, 10, 20, 30, 40, and 50 min. and 1, 2, 8, and 4 hrs. and then water-quenched. The decrease in  $\sigma_1$  with the duration of tempering was gradual, and  $\Delta H$  increased simultaneously; decompn. of residual austenite was not detected in any of these tests.

I. Bencowitz

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SADOVSKIY, V. D.

Effect of aluminum deoxidation in tempering on the irreversible temper brittleness of structural steel alloys. B. N. Sokolov, G. V. Gakharov, and V. D. Sadovskiy. *Trudy Inst. Fiz. Metal. Akad. Nauk S.S.S.R., Ural. Filial* 1986, No. 18, 20-5; cf. preceding abstr. -- Alloys of 30KhN4 without Al and with 0.02-0.16% Al were prepd. in open magnesite crucibles. Specimens 10 X 10 X 55 mm. were oil-quenched from 1100°, tempered for 1 hr. at temps.  $t$ , from 200 to 500° in 50° intervals, quenched in water, and notched for tensile tests. The curves of the impact strength  $\sigma_k$  vs.  $t$  of the alloy without Al and with only 0.03% Al varied very little: a pronounced min. at 350° followed by a sharp rise and a shallow min. at 500° (indicating the presence of both irreversible and reversible brittleness). The fracture at the brittleness range was coarse-grained. The  $\sigma_k$  vs.  $t$  curves of the alloys with 0.05 and 0.16% Al exhibited only a slight min. at 350°, and the fracture showed an increased amt. of fine-grained austenite. To det. whether the effect of Al, re-

ducing the irreversible brittleness, was due to the formation of Al nitride; thus preventing the formation of Cr and Mn nitrides (cf. Schrader, *et al.*, C.A. 44, 4399) or to the increase of fine-grained structure (cf. Houdremont and Schrader, C.A. 33, 3723) alloys contg. 0.03 and 0.16% Al were prepd. *in vacuo* (0.05-1 mm. Hg). The excess of Al secured the absence of N and 0.03% of Al was not enough to affect  $\sigma_k$ . The  $\sigma_k$  vs.  $t$  curves of both alloys were practically identical, passing through a sharp min. at 350° and a shallower one at a higher level at 500°. No effect on the grain structure was noted. Conclusion: the effect of Al on  $\sigma_k$  was due to the increase of the fine structure rather than to the prevention of Cr and Mn nitride formation.

I. B.

SADOVSKIY, V. I.

Effect of plastic deformation in the austenite state on the character of embrittlement of structural steel alloys developed in tempering. L. V. Smirnov, E. N. Sokolov, and V. I. Sadovskiy. Trudy Inst. Fiz. Metal. Akad. Nauk S.S.S.R., Izv. Filial 1956, No. 18, 30-60. The effect of hot rolling on the tendency of steel to develop irreversible (1st-order) and reversible (2nd-order) brittleness was investigated by the following series of expts. with steels containing C 0.37-0.38 and Cr 1.33-1.53% the following: 35 KhGCA; Mn 1.02, Si 1.30, P 0.028, S 0.020%; 37KhN3A; Mn 0.36, Si 0.4, Ni 3.3, P 0.018, S 0.010%. (1) After heating for 30 min. at 1200° the specimens were treated as follows: (a) rolled at 1200° and oil-quenched immediately; (b) oven-cooled to 900°, rolled, and immediately oil-quenched; (c) oven-cooled to 900° and oil-quenched immediately without rolling. The impact strength  $\sigma_k$  of (a), (b), and (c) of the 2 alloys were 1.0 and 2.3; 5.5 and 0.5; 0.5 and 1.2 kg./sq. cm., resp. The fracture of (a) was brittle, fine-grained, intergranular, characteristic of the 2nd-order brittleness; that of (b) was amorphous without a trace of brittleness; and that of (c) was coarse-grained, intragranular. The difference between (a) and (b) suggested the possibility of instantaneous austenite recrystn. at 1200°. The difference between (b) and (c) emphasized the effect of hot deformation on brittleness. (2) Specimens held for 1 hr. at 1000° were oven-cooled to 900° and (a) immediately oil-quenched without rolling and (b) hot-rolled to 20% reduction and then oil-quenched. Pieces of both groups were then tempered for 1 hr. in a salt bath at 50° intervals in the range of 200-600°. The hardness as a function of the tempering temp.,  $H$ , were parallel curves decreasing slightly as  $T$  increased. The curves of  $\sigma_k$  vs.  $T$  of (a) passed through a min. at 350°, a max. at 450°, and another min. at 600°. The same curves of pieces

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(b) dipped slightly at 350-400° and then rose continuously. These variations were more pronounced with 37KhN3A than with 36KhGCA. (3) The effect of the degree of rolling on  $\alpha_1$  was detd. on pieces oven-cooled from 1160° to 900°, rolled to 10, 20, and 30% reduction, and oil-quenched immediately. The max. rise of  $\alpha_1$  was completed at the lowest, 10%, reduction. Further rolling had no effect on  $\alpha_1$ ; in some cases it was slightly decreased. This was an indication that the effect of hot-rolling was not due to the fibrous grain and fracture, for practically all of the elongation, and fibrousness, was completed at 10% reduction. (4)  $\alpha_1$  as a function of the temp. of hot-rolling increased linearly with the temp., passed through a rounded max. at 900-1000°, and then decreased linearly. These expts. were made with alloy 40Kh.

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3N4 contg. C 0.34, Mn 0.27, Si 0.21, Cr 3.23, and Ni 4.64%. The other alloys gave similar results. (5) The effect of the time held at the rolling temp. after rolling before water quenching was detd. on pieces preheated at 1200° and rolled at 1200, 1100, 1000, 900, and 800° and held at these temps. for 1, 5, and 20 min. The function  $\alpha_1$  vs. the time held at the rolling temp. decreased exponentially, and this effect increased with the rolling temp. Thus the effect of hot-rolling reducing brittleness was lost when sufficient time for the recrystn. of austenite was allowed. Micrograins of the fractured pieces indicated that at 1200° this recrystn. was practically instantaneous and that it stopped by immediate



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quenching. (8) The variation of  $\alpha_s$  as a function of the test-  
ing temp. was detd. in the range of  $+140$  to  $-200^\circ$ .  $\alpha_s$  be-  
gan to decrease into the brittleness range at  $0^\circ$  when hot-  
rolled and at  $+100^\circ$  when not rolled. Conclusion: Hot-  
mech. working reduced both reversible and irreversible tem-  
per brittleness providing recrystn. of austenite was instantly  
arrested. Both types of brittleness are similar processes but  
initiated by different causes. I. Bencowitz

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SADOVSKIY, V.D.

Effect of preliminary superheating of steel on the appearance of reversible temper brittleness. V. V. Smirnov and V. D. Sadovskiy. *Trudy Inst. Fiz. Metal., Akad. Nauk S.S.S.R., Ural. Filial* 1956, No. 18, 57-65. The effect of intra-granular texture of superheated steels on the appearance of reversible temper brittleness (at 550°) was studied. The following tests were made with steels 37KhN3A (cf. preceding abstr.): (1) Wedges ground from pieces which had been oil-quenched from 1300° were heated with an elec. current at the rate of 300°/sec. so that the temp. at the pointed edge was at 1350°, above the  $A_c-A_{c1}$  crit. points. The hardness,  $H_{\text{RC}}$ , at 12 evenly spaced sections was detd. and the macro- and micrograins of the same sections examd. The  $H_{\text{RC}}$  of the first 1-5 sections (from the wide edge) where none of the  $\alpha \rightarrow \gamma$  transformation occurred was 38-41  $R_c$ , whereas that of the sections 6-12 was 52-40  $R_c$ . The macrostructure (x3) of sections 1-10 remained coarse, unchanged, whereas that of section 11-12 changed abruptly and completely into a fine-grained structure (temp. above  $A_{c1}$ ). The corresponding micrograins (x380) indicated a gradual change: at first annealing of martensite, then the appearance of fine grains of austenite between the original grains (above  $A_1$  at section 5), and finally the formation of an unoriented network of needle-like martensite (section 12). The processes of recrystallization could be explained only by the more recent theories (cf. Arkharov, et al., *C.A.* 44: 4847e). The abrupt change from coarse to fine-grained structures corresponded to Chernov's point  $\delta$  (cf. *C.A.* 48: 1219g) defined as that crit. temp. below which the fracture surface did not change, i.e. the structure did not change and above which the structure changed appreciably. For steel 37KhN3A this point was at 950-1000°. (2)  $\sigma_s$  of pieces quenched from 1300° and then again quenched from 600 and 1100° was 18 and 17 kg./sq. cm. when tempered for 1 hr. at 650° and then quenched in water and 5.5 and 9.8 kg./sq. cm. when tempered at 650°, water.

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quenched, and again tempered at 550° and oven-cooled. The fracture of pieces tempered below Chernov's point  $b$  was coarse, and that of pieces tempered above point  $b$  was fine-grained, the fracture passing through the boundaries of the new austenite grains. Heating above point  $b$  eliminated the effect of superheating. (3) The effect of testing temp. in the range of +20 to -180° was detd. on specimen superheated at 1250° and not superheated and then oil-quenched from 850 and 1050°; specimens of each group were then (a) tempered for 1 hr. at 550° and water-quenched; (b) tempered for 1 hr. at 550°; water-quenched, and then tempered for 20 hrs. at 550° and oven cooled. The values of  $\sigma_k$  of specimen treated in (b) were much lower and decreased more sharply with the testing temp. than those treated as in (a).  $\sigma_k$  of superheated specimens were more drastically affected. In all cases a type of texture brittleness was noted. (4) To det.

the effect of removing the texture the following expt. was made: Specimens superheated at 1250° were kept in a muffle furnace at 630° for 10 hrs. The micrograins (x380) indicated a fine-grain pearlite structure. Conclusion: superheated steels which develop temper embrittlement accompanied by martensite and intermediate austenite transformation can be restored by secondary annealing above the Chernov's point  $b$  followed by normal tempering above  $A_c$ . Cooling from a high temp., favoring the development of pearlite-troostite structure, may eliminate the need for secondary treatment. I. Bencowitz

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SADOVSKIY, V. D.

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Effect of nickel on the impact strength of manganese austenite steels

Effect of nickel on the impact strength of manganese austenite steels. V. D. Sadovskiy and T. Biryulin. *Trudy Inst. Fiz. Metal. Akad. Nauk S.S.S.R., Ural. Filial* 1956, No. 18, 66-71. — The effect of Ni on the tensile properties of C-Mn steels at low temp. was detd. (a) after quenching in water and in water followed by liquid N in the temp. range from 700 to 1300° and (b) after quenching in water from 1150°. In the range of testing temps. from +20 to -180° the impact strength  $\alpha_1$ , the hardness  $H_{\alpha_1}$ , and the  $\alpha$ -phase content were detd. on steels 60G12N(4-12) and 20G12N(4-12) contg. C 0.6 and 0.2, Mn about 12, and Ni 4, 8, and 12%. All specimens had high values of  $\alpha_1$  and no magnetic properties, i.e., the  $\alpha$ -phase did not appear even after cooling in liquid N. On the other hand, steels contg. less than 0.6% Ni such as 110G12 (Hatfield's steel) and 60G12 as well as those contg. less than 0.35% Mn such as 60N16 and 20N24 (C 0.59 and 0.12, Mn 0.35 and 0.27, Ni 16.37 and 24.21%) developed as much as 12-15%  $\alpha$ -phase. After cooling in liquid N the latter increased and  $\alpha_1$  decreased sharply. The values of  $\alpha_1$  of alloys 20G12N(4-12) were affected differently by the testing temp. That of 20G12N12 remained high at 38 kg./sq. cm. from +20 to -50° and then decreased to 30 kg./sq. cm. at -180°, whereas that contg. 8% Ni (20G12N8) was 30 kg./sq. cm. from +20 to -40°

and then dropped to 8 kg./sq. cm. at -180°, and that of 20G12N4 (4% Ni), dropped from 30 at +20° to about 6 at -50° and to practically zero at -180°. Increasing the Ni content had a similar effect on  $\alpha_1$  of the high C series 60G12N(4-12). Throughout the entire temp. range  $\alpha_1$  of this group was higher than that of 110G12 (C 1.11, Mn 12.58, Ni 0.58%), and that of the latter was higher than the  $\alpha_1$  of 60-

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PIRYULIN, V. T.; SADOVSKIĬ, V. D.

G12 (C 0.66, Mn 12.08, Ni 0.48%). Apparently, 4% Ni increased  $\alpha$ , more than 0.5% C, despite the fact that the martensite point was lower in the latter. Stability of austenite toward its transformation to the  $\alpha$ -phase under plastic deformation is probably detd. more by the degree of supercooling in relation to the temp. of the metastable equil.  $\alpha$ - and  $\gamma$ -solus. The brittleness of Mn austenite at low temps. was attributed to the  $\alpha$ -phase formed during the progress of the testing and the effect of Ni to its stabilizing of austenite.

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*fra* *RS* *carb*

SOV/124-57-9-11090

Translation from: Referativnyy zhurnal. Mekhanika, 1957, Nr 9, p 167 (USSR)

AUTHORS: Biryulin, V. T. Sadovskiy, V.D.

TITLE: On the Problem of the Effects of Cold Working Upon the Mechanical Properties of Quenched Steel (K voprosu o vliyaniy obrabotki kholodom na mekhanicheskiye svoystva zakalennoy stali)

PERIODICAL: Tr. In-ta fiz. metallov. Ural'skiy fil. AN SSSR, 1956, Nr 18, pp 72-98

ABSTRACT: Bibliographic entry

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ISUPOV, V.I.; MASHURA, G.P.; SADOVSKIY, V.D.

Development of temper brittleness in steel drawing. Trudy  
Inst. fiz. met. no.18:99-105 '56. (MLRA 10:2)

(Steel--brittleness) (Drawing (Metalwork))

SOV/137-58-9-19827

Translation from: Referativnyy zhurnal, Metallurgiya, 1958, Nr 9, p 246 (USSR)

AUTHORS: ~~Sadovskiy, V.D.~~, Malyshev, K.A., Sokolov, Ye.N., Smirnov, L.V., Bogacheva, G.N., Biryulin, V.T., Petrova, S.N.

TITLE: The Effect of High-temperature Plastic Deformations on Brittleness of Hardened Steels During Tempering and Aging (Vliyaniye plasticheskoy deformatsii pri vysokikh temperaturakh na khrupkost' pri otpuske i starenii zakalennykh staley)

PERIODICAL: V sb.: Issled. po zharoprochn. splavam. Vol 2. Moscow, AN SSSR, 1957, pp 76-91

ABSTRACT: Investigations were performed in order to determine the effect of thermomechanical treatment (TMT) procedures (plastic deformation in the austenite state combined with immediate quenching of austenite which had not been allowed to recrystallize) on the  $a_k$  of steels 35KhGSA and 60Kh4G8N8V, and on the  $a_k$  of special grades of heat-resistant steels. Mechanical properties of the metals involved were measured and metallographic investigations were performed. The TMT increases the  $a_k$  value of austenite steels which are susceptible to aging (thermal brittleness). The lower limit of the temperature of TMT

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SOV/137-59-5-10908

187100  
Translation from: Referativnyy zhurnal, Metallurgiya, 1959, Nr 5, p 210 (USSR)

AUTHORS: Biryulin, V.T., Sadovskiy, V.D.

TITLE: The Problem of the Effect of Isothermal Quench-Hardening on the Mechanical Properties of Steel

PERIODICAL: V sb.: Materialy Nauchno-tekhn. konferentsii po probl. zakalki v goryachikh sredakh i promezhutochn. prevrashcheniyu austenita, Vol 1, Yaroslavl', 1957, pp 162 - 179

ABSTRACT: The authors compared  $a_k$  and  $R_C$  after tempering of 40KhNMA, 35KhGSA and 38KhMYuA steel, subjected to conventional and isothermal quench hardening at salt temperatures of  $200^\circ - 550^\circ\text{C}$  and holding from 5 minutes to 128 hours. They investigated magnetometric kinetics of the isothermal transformation and the amount of residual austenite after tempering. It was established that the advantage of isothermal quench-hardening over conventional quench-hardening by the value of  $a_k$  (at lower experimental temperatures down to  $-100^\circ\text{C}$ ) was observed only at isothermal quench-hardening temperatures as high as  $250^\circ - 350^\circ\text{C}$ . Such temperatures corresponded

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# The Problem of the Effect of Isothermal Quench-Hardening on the Mechanical Properties of Steel

to the range of irreversible brittleness in tempering ( $R_C$  42 - 48). The advantage of isothermal quench-hardening was not noticed at high tempering of steels which were not sensitive to reversible brittleness. Extended holding at temperatures of isothermal quench-hardening as high as 250° - 350°C (hours and tenths of hours) did not yet entail brittleness. However, at isothermal quench-hardening temperatures of 350° - 450°C,  $a_k$  was considerably reduced already when holding for  $> 5 - 15$  min. The drop of  $a_k$  does not always correspond to the reduced amount of residual austenite. This is explained by the effect of other factors, such as transformation of residual austenite during the process of impact tests, and coarsening of the disintegration products at high isothermal quench-hardening temperatures. A connection is noticed between the process of brittleness at temperatures of isothermal quench-hardening  $\leq 300^\circ\text{C}$ , producing intercrystalline breaks after very prolonged holding, and more rapidly developing irreversible brittleness of quench-hardened steels in tempering. It is supposed that the

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peculiarities of the structure obtained in the upper zone of the medium stage of disintegration affect the development of brittleness in the case of isothermal quench-hardening at 350° - 400°C. They also affect the inhibited development of reversible brittleness in tempering after isothermal quench-hardening. ✓

L.F.

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3 Adovskiy, V.D.

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AUTHOR: Sokolov, E.N. and Sadovskiy, V.D.

TITLE: Influence of plastic deformation by tension on the notch impact strength of alloy structural steel in the case of exclusion of processes of recrystallisation of austenite. (Vliyanie goryachey plasticheskoy deformatsii rastyazheniem pri iskl'yuchenii protsessov rekristallizatsii austenita na udarnuyu vyazkost' konstruktsionnoy legirovannoy stali.)

PERIODICAL: "Fizika Metallov i Metallovedenie", (Physics of Metals and Metallurgy), 1957, Vol.IV, No.1 (10), p.187, (U.S.S.R.)

ABSTRACT:

The authors carried out tests of hardening during deformation in tension of a Cr-Si-Mn steel of the following composition: 0.32-0.39% C, 1.10-1.40% Si, 0.80-1.10% Mn, 1.10-1.40% Cr, 0.40% Max Ni. A decrease was observed in the development of reversible temper brittleness which is accompanied by an increase in the impact strength and a changeover to tough ductile fracture without any visible traces of brittle inter-crystalline fracture. The deformation in tension of the specimen in the austenitic state was effected in a special attachment to an hydraulic press. For excluding re-crystallisation of the austenite an increased deformation rate of 5 mm/sec was applied with rapid hardening after completion of the stretching. 3 Russian references.

Institute of Metal Physics,  
Ural Branch of the Ac.Sc.

Recd. November, 2, 1956.

AUTHOR: Sadovskiy, V. D., Dr. of Techn. Sc. Prof.

TITLE: Summary of the discussion on temper brittleness.  
(Itogi diskussii po otpusknoy khrupkosti).

PERIODICAL: "Metallovedenie i Obrabotka Metallov" (Metallurgy and  
Metal Treatment), 1957, No.6, pp.24-42 (U.S.S.R.)

ABSTRACT: An attempt is made to summarise the new features  
brought out by the extensive and prolonged discussion  
published in this journal relating to the phenomenology  
and the theoretical conceptions of the nature of  
temper brittleness. Only the reversible temper  
brittleness is considered, namely, the phenomenon  
of reduced impact strength of some structural steels  
after tempering in the range of 450 to 575 C and  
after tempering at 650 to 700 C with subsequent slow  
cooling or after additional tempering of steel in the  
range of 450 to 575 C if the metal was previously  
tempered at higher temperatures and subsequently  
rapidly cooled. In a number of contributions (1-3),  
(11), (18), (21), (22), (54) the view was expressed  
that development of temper brittleness brings about  
an increase in the temperature of transition to a  
brittle fracture in series notch impact tests and that  
the sensitivity of the steel to temper brittleness  
should be characterized by the degree of this increase,  
i.e. by the temperature difference between the curve  
characterizing the temperature dependence of the

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Summary of the discussion on temper brittleness. (Cont.)

impact work of the steel treated to be in the tough state and the equal curve applicable for the same steel in the brittle state; the tendency to ageing has been similarly characterized for a long time by the displacement of the temperature of transition to the brittle state. The author of this paper considers the assumption correct that the displacement of the curves of cold brittleness relative to each other is an indication of the existence of temper brittleness, whilst the magnitude of the displacement can be used only as a very rough approximation of the degree of development of brittleness. All the contributors to the discussion agree that fracture during development of reversible brittleness is accompanied by a fracture which is inter-crystalline relative to the original austenite grain. Recent investigations have enabled the development of reagents which permit to distinguish reliably the state of reversible brittleness from the microstructure. It was also found (27,28) that steel in the temper brittle state has a considerably reduced strength and ductility if subjected to static tensile stresses at sufficiently low temperatures. Equally, temper brittle steel has a tendency to crack up in the case of rod drawing (29). Nickel steels which are not prone to develop temper brittleness if Cr or P is

Summary of the discussion on temper brittleness. (Cont.)  
introduced (30, 31); high Cr steel is practically insensitive to brittleness but it becomes highly brittle if additionally alloyed with nickel (30). Interesting data were published on the influence of phosphorus; in the case of increase P contents to 0.1 to 0.2% the steel may have a high impact strength immediately after hardening and high temperature tempering accompanied by rapid cooling but will become brittle after having been for several hours at room temperature (32, 55, 56). Data were also given on the insensitivity to brittleness of alloys with extremely low C contents (43). Views have been expressed that ordinary cooling, for instance, of a standard specimen in water, is adequate for suppressing processes leading to the temper brittleness of carbon steels, whilst additional tempering or slow cooling will bring about temper brittleness. Additions of silicon to nickel steel which is insensitive to temper brittleness will make such steel highly sensitive. Some of the available data indicate a weakening of the brittleness under the influence of deoxidation with aluminium (39), although these data can be interpreted as being the result of an indirect influence by changing the grain size. Experiments have shown that cold plastic

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Summary of the discussion on temper brittleness. (Cont.)  
deformation improves the impact strength of steel which is in the brittle state and also reduces the tendency to temper brittleness of such steel. Much space is devoted to discussing new views relating to the theory of temper brittleness. The summary of the discussion is followed by the following conclusions: the temper brittleness is the result of reduced brittle strength caused by the separation of certain phases at the boundaries of the grains and of the mosaic blocks. This separation proceeds in the case of slow cooling after tempering (annealing) or during additional tempering (ageing) of material subjected to tempering (annealing) at more elevated temperatures and subsequent rapid cooling. The separation of phases which cause brittleness is the result of disintegration of the solid solutions which form during heating, whilst tempering or during annealing. The possibility of obtaining saturated solid solutions and their subsequent decomposition into alloy systems which at a given temperature range form stable solid solutions is apparently due to the non-uniform distribution of surface-active admixtures and polycrystalline solid solutions. It can be assumed that in current grade steels P plays a decisive role in processes which bring about reversible

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Summary of the discussion on temper brittleness.<sup>658</sup>(Cont.)

temper brittleness. In an editorial note it is stated that this summary closes the discussion on the subject which was started in February, 1956 and that the Editorial Board agrees with the view expressed by the author that at present sufficiently logical and adequate experimental data are available to gain a conception of the physical nature of this phenomenon but so far no theory of the phenomenon exists which has been adequately confirmed experimentally. 5 figures, 58 references, 42 of which are Slavic.

ASSOCIATION: Ural Branch Ac.Sc. U.S.S.R., Institute of Metal Physics.  
(Ural'skiy Filial AN SSSR, Institut Fiziki Metallov).

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SADOVSKIY, V.D.

129-12-1/11

AUTHOR: Sadovskiy, V.D., Doctor of Technical Sciences, Prof.

TITLE: Development of the theory of heat treatment of steel in the work of Soviet scientists. (Razvitiye teorii termicheskoy obrabotki stali v rabotakh sovetskikh uchennykh)

PERIODICAL: Metallovedeniye i Obrabotka Metallov, 1957, No. 12, pp. 2-14 (USSR)

ABSTRACT: The author limits his review of the contribution of Soviet scientists in the field of heat treatment to simple steels, i.e. carbon and alloy steels, without dealing with heat treatment problems which relate to special physical properties of stainless, heat and scale resistant steels, etc., chemical-heat treatment, surface hardening, electro-thermal treatment, recrystallisation annealing, homogenization, etc. The aim of the author was to characterize briefly the theory of the main heat treatment operations, namely annealing, hardening and tempering, which are of importance for any steel in which polymorphous transformation is involved. The author believes that the fundamental task of the theory of heat treatment consists in elucidating the physical nature of the phenomena. The central problem in the theory of heat treatment during the last thirty years has been that of hardening

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Development of the theory of heat treatment of steel in the work of Soviet scientists. steel and it is this problem which is dealt with in the first instance. A classical work in this field is that of D. K. Chernov "On manufacturing armour piercing steel shells" published in 1855 and many of his ideas were rediscovered in the 1930's. The development of theoretical work in metallurgy during the last 20 to 30 years was characterized by intensive study of the structural mechanism and the kinetics of phase transformations, whereby attention was concentrated on the study of the kinetics and mechanism of structural transformations of super-cooled austenite in carbon and alloy steels and it is this problem which was mainly studied over a number of years by the schools headed by S. S. Shteynberg, G. V. Kurdyumov, N. A. Minkevich and of N. T. Gudtsov. Most of the sections of the paper relating to hardening of steel is devoted to prewar developments. For a number of years the school of G. V. Kurdyumov was engaged in studying the fine crystalline structure of hardened steel and this resulted in elucidating the factors bringing about a high hardness during hardening; blurring of interference lines is

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fundamentally due to intensive Type II distortions. In elucidating this problem investigations by M. P. Abruzov of the structure of isolated martensite crystals produced by anodic dissolution of hardened steel, played an important role. In isolated martensite crystals, the tetragonal nature of the lattice is conserved and Type II stresses are practically absent so that only a weak blurring of the interference lines is observed, which is due to a low magnitude of the areas of coherent scattering, the value of which is  $2.3 \times 10^{-6}$  cm. Type II distortions are attributed to elastic deformations of the martensite crystals caused by forces external relative to those crystals. Therefore, the high resistance to plastic deformation of hardened steel cannot be associated with the features of the structure of the hardened specimen, since every martensite crystal possesses a high elastic limit. The main and specific cause of the increased strength of hardened steel consists in the formation of  $\alpha$ -solid solution which is over-saturated with carbon and this causes the changes in the lattice and in the inter-atomic distances, formation of large static lattice

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of Soviet scientists.

distortions, considerable increase of the limit of elastic deformation of  $\alpha$ -phase crystals and weakening of inter-atomic bonds. The latter fact cannot cause an increase in strength but an increase is observed in the resistance of hardened steel to plastic deformation in spite of weakening of the inter-atomic bonds in the martensite, since the real strength of the crystals is considerably below the theoretical strength, i.e. that representing the effort required to break the inter-atomic bonds, with the assumption that the bonds of all the atoms are broken simultaneously. A. F. Ioffe and his school have shown that the low real strength is explained by the fact that the cracks along the surface of fracture do not occur simultaneously. The fundamental characteristics of the phenomenology of the martensite transformation in steel were elucidated as a result of a large series of experiments of which those of S. S. Shteynberg and his school in Sverdlovsk, A. P. Gulyayev in Moscow and G.V. Kurdymov and his team are the most important. The specific feature of martensite transformation is the fact that it takes

Card 4/12 place without any change in the concentration of the

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solid solution and consists of a sudden reconstruction of the crystal lattice. The possibility of causing transformations by applying external mechanical forces during static deformation led to the assumption that martensitic transformation is caused by stresses which develop in the austenite during the cooling process (Ye. Sheyl', S. S. Shteynberg and A. A. Bochvar); this theory is to a considerable extent supported by A. P. Gulyayev and S. F. Yur'yev. The view that the martensitic transformation consists of a regular reconstruction of the lattice, not involving inter-change of the location of the individual atoms but only a relative displacement of these atoms by a distance not exceeding the inter-atomic distance, permits elucidation of the high speed of transformation at low temperatures in absence of thermal fluctuations. Work is also reviewed relating to the cooling speed; the Moscow school (I. L. Mirkin and others) has considered for the first time the process of eutectoidal decomposition of super-cooled austenite from the point of view of the general crystallisation scheme, associating the total speed of

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elements on the stability of super-cooled austenite did not reveal the causes of this influence. The theories linking the influence of alloying elements with formation of alloyed carbides during decomposition of the austenite are also unsatisfactory, since some Soviet authors (N. N. Sirota, M. Ye. Blanter and others) have proved experimentally and theoretically that, at the initial stages of decomposition of the austenite, a carbide phase usually forms which does not differ in composition from the original austenite. In the work published by R. I. Entin and others of the Central Institute of Ferrous Metallurgy (Tsentral'nyy Institut Chernoy Metallurgii) the necessity is emphasized of taking into consideration the influence of alloying elements on the speed of  $\gamma$  to  $\alpha$  transformation. V. I. Arkharov associates the intensive effect of small admixtures with a positive or negative adsorption of these at the boundaries of the austenite crystallites, which are usually loci of localisation of primary formations of the new phase in transformations of a diffusional character. It is regretted that, as regards application to the concrete problem of the mechanism of

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the effect of alloying elements on the hardenability of steel, the above mentioned theories have, so far, not been adequately verified experimentally. A.I. Stregulin, L. M. Pevzner, V. D. Sadovskiy and others have carried out extensive investigations relating to the mechanical properties of intermediate transformation products, as compared with the properties of tempered martensite, which form the basis for working out regimes for step-wise and isothermal hardening. The magnitude and direction of the changes in the specific volume during hardening have been extensively studied but relatively few quantitative studies have been made on the magnitude and distribution of internal stresses (M. V. Yakutovich, D. G. Kurnosov and others); the amount of knowledge available on internal stresses lags far behind the achievements in studying the structural mechanism of phase transformations during hardening. Work relating to tempering of hardened steel is reviewed in a separate chapter, mentioning that of greatest interest are the X-ray studies of G.V. Kurdyumov and his team, predominantly in the Ukraine, which confirmed long existing conceptions that, during tempering, a gradual

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decomposition takes place of the solid solution reverting the steel into a stable state of a mixture of  $\alpha$ -iron and carbides. This process consists of a number of stages, the first taking place between room temperature and 300 to 350°C, consisting of gradual separating out of carbon from the martensite which is the more complete the higher the temperature and the duration of annealing. The second stage of martensite decomposition is characterized as a homogeneous, single phase or continuous process taking place during gradual decrease of the carbon concentration in the solution. So far, the nature of the carbide which separates out during the initial stage of martensite transformation has not been finally determined but there is no doubt that at 300 to 400°C carbide with a cementite lattice forms; it is assumed that at lower temperatures another type of carbide forms. The third stage of tempering is characterized by a considerable change in the specific volume of the steel and considerable thermal effects, the magnitude of which is strictly proportional to the carbon content of the steel; this transformation

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proceeds at temperatures approaching 350 to 450°C. The assumption that at the initial stage of tempering a carbide forms which is different from cementite provides a basis for elucidating the nature of the third transformation which can be associated with transformation of low temperature carbide into ordinary cementite. Quantitative study of this practically important phenomenon has been made by S. Z. Bokshteyn. G. V. Kurdyumov and other Soviet authors have worked intensively on inter-relating the changes in the state of the  $\alpha$ -phase during tempering with the orientation of the crystals, type II stresses and the character of the block structure. In steels alloyed with elements which impede the separation of carbon from the martensite, the formation is possible of disperse special carbides even in the range of 500°C, which leads to occurrence of additional dispersion distortions (L. I. Lysak). Very brief chapters are devoted to annealing of steels and softening annealing of alloyed steels and to annealing of beyond eutectoidal steels to obtain granular cementite.

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of Soviet scientists.

The final chapter deals with annealing for the purpose of improving a coarse grain structure. On the basis of results obtained during recent years, the elementary conception on the existence of a phase recrystallisation during heating of steels can be supplemented by taking into consideration a number of important factors (K. A. Malyshev, V. D. Sadovskiy, N. V. V'yal, B.G. Sazonov and others). The process of phase crystallisation consists of two stages, namely, the phase transformation leading to the formation of a hardened austenite and associated, as regards orientation, with the initial structure and recrystallisation of the austenite as a result of which the phase hardening is eliminated and also the intragranular texture. The main practical conclusion is that in evolving heat treatment regimes for improving coarse grain structures, it is necessary to take into consideration not only the critical phase transformation points but also the existence and the position of the recrystallisation temperature of the austenite. A number of particular theoretical and practical problems of heat treatment

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assume a new explanation and, for instance, the B point of Chernov can be interpreted as the temperature of the recrystallisation of austenite as a result of phase hardening which, in the general case, does not coincide with the  $Ac_3$  point. The physical meaning of the practically applied regimes for correcting the consequence of over-heating of steel (double annealing, double normalisation, etc.) has also been elucidated, these regimes are aimed at liquidating the structural heredity of the steel, the physical basis of which is the manifestation of the orientational conformity of phase transformations. In the conclusions the author emphasizes that a number of specialised research establishments have been created in the Soviet Union, the task of which is to study, on a very wide basis, problems relating to metals and alloys. Scientific teams have been created who work in the fields of metallurgy, metallography and physics of metals, as well

Card 12/12 as in studying the theory of heat treatment.

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SADOVSKIY, V. D

129-4-1/12

AUTHORS: Gaydukov, M. G., Candidate of Technical Sciences, and  
Sadovskiy, V.D., Doctor of Technical Sciences, Prof.

TITLE: Influence of plastic deformation on martensitic  
transformation. (Vliyaniye plasticheskoy deformatsii  
na martensitnoye prevrashcheniye).

PERIODICAL: Metallovedeniye i Obrabotka Metallov, 1958, No.4,  
pp. 2-7 + 2 plates (USSR).

ABSTRACT: The experiments were carried out on austenitic steels  
produced in a high frequency furnace. Ingots weighing  
8 kg were forged into quadratic rods of 14 x 14 mm.  
For obtaining the austenitic state, alloying was effected  
with Cr, Ni, Mn. The chemical analyses of the tested  
steels are entered in Table 1. For investigating the  
stability of the austenite against martensite trans-  
formation due to the effect of plastic deformation  
square specimens of 10 x 10 x 70 mm were produced. The  
specimens were heated in a salt bath to 1150°C and  
quenched in oil and, following that, the decarburised  
layer was ground off. The plastic deformation was  
effected with hand operated rolls for rolling square  
profiles. The degree of austenite into martensite  
transformation during the deformation was determined by

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Influence of plastic deformation on martensitic transformation.

the magnetometric method. The location of the martensitic points and the intensity of transformation of austenite into martensite during cooling were investigated by the magnetometric method; the specimens were of 3 mm dia and 50 mm long. The cooling speed to the temperature of liquid nitrogen was 5°C/min except for particular cases in which the cooling speed was lower still. The following conclusions are arrived at:

1. The stability of alloyed austenite in the case of plastic deformation is determined fundamentally by the relative positions of the martensitic point and of the deformation temperature. The intensity of transformation will be the smaller the larger the difference between the temperature of the martensitic point and the temperature of plastic deformation. In some alloy steels with a low martensitic point, the martensite will not form at all if the deformation is effected at room temperature or at higher temperatures.

2. In addition to the basic temperature dependence, the stability of alloyed austenite as regards plastic deformation is also determined by the chemical composition

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Influence of plastic deformation on martensitic transformation.

of the steel. For steels with equal martensitic transformation temperatures, those alloyed with Ni and Cr will be more stable than those alloyed with Ni and Mn.

3. Preliminary plastic deformation of austenite reduces the martensitic point and changes the kinetics of martensitic transformation during subsequent cooling. Lowering of the martensitic point takes place not only when there is a partial transformation of austenite into martensite during deformation but also in absence of martensite transformation and only as a result of plastic deformation. Lowering of the martensitic point after preliminary plastic deformation is characteristic not only for steels but also for carbon free iron alloys.

4. The state of phase hardening occurring as a result of reversible transformation of the  $\alpha$ -phase into the  $\gamma$ -phase during heating of the carbon free alloy iron-nickel-manganese leads to a reduction of the martensitic point during subsequent cooling and to a change in the kinetics of martensitic transformation. Influence of the phase hardening on the kinetics of

Card 3/4 martensite transformation during cooling is similar to

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the influence of external plastic deformation.

5. The position of the martensitic point depends on the grain size of the austenite, particularly in Cr-Ni steels which are subjected to martensitic transformation in the range of sub-zero temperatures.

There are 11 figures, 2 tables and 7 references - 5 Russian, 1 German, 1 English.

ASSOCIATION: Ural Branch of the Ac.Sc. USSR (Ural'skiy Filial AN SSSR).

AVAILABLE: Library of Congress.

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*SADOVSKIY, V.D.*

129-58-5-2/17

AUTHORS: Gaydakov, M.G., Candidate of Technical Sciences and  
Sadovskiy, V.D., Doctor of Technical Sciences, Professor.

TITLE: Changes in the Hardening Coefficient Connected With the Development of Martensitic Transformation During Plastic Deformation (Izmeneniye koeffitsiyenta uprochneniya, svyazannoye s razvitiyem martensitnogo prevrashcheniya pri plasticheskoy deformatsii)

PERIODICAL: Metallovedeniye i Obrabotka Metallov, 1958, Nr 5, pp 4-8 (USSR)

ABSTRACT: In a number of austenitic steels plastic deformation at temperatures approaching the martensitic point brings about transformation of the austenite into martensite and, therefore, after the usual decrease in the hardening coefficient, a gradual increase of this coefficient will take place. The authors of this paper investigated the particular case of hardening of austenitic steels in which the deformation is accompanied by a transformation of the austenite into martensite. In addition to austenitic steels, a carbon-free alloy of iron with nickel was also tested. Rods of the tested alloys (the compositions of which are entered in a Table, p 4) Card 1/3 were hardened from 1200°C and from these, specimens of

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Changes in the Hardening Coefficient Connected with the Development  
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3 mm dia, 30 mm rated length were produced by machining. For investigating the influence of preliminary plastic deformation, square blanks were used which were produced by rolling with various reductions. From these blanks specimens were produced for tensile tests which were carried out on a test machine (IM-4R) with automatic recording of the diagrams. From the obtained results the diagrams of the real stresses were plotted and the hardening coefficients were calculated for various degrees of deformation of each specimen starting from 5%. In Fig.1 the change of the coefficient of hardening during tension is graphed for nickel steels. In Fig.2 the influence of preliminary deformation and of the quantity of martensite on the change of the coefficient of hardening during tensile tests is graphed for the steel 25N24M2. In Fig.3 the influence is graphed of the preliminary deformation on the changes of the shape of the load vs. elongation curve of the alloy N29 (the respective compositions are entered in the Table, p 4). On the basis of the obtained results, it is concluded that the character of the change of the hardening

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Changes in the Hardening Coefficient Connected with the Development  
of Martensitic Transformation During Plastic Deformation

coefficient during deformation of austenitic steels is directly associated with the difference in the stability of the austenite with respect to martensitic transformation. Formation of martensite during plastic deformation leads to an increase in the hardening coefficient. Some of the features of the stretching of austenitic steels (change in the load, presence of two maxima) characterise the mutual relation between the processes of plastic flow and the martensitic transformation.

There are 3 figures, 1 table and 14 references, 10 of which are Soviet, 3 German and 1 English.

ASSOCIATION: Ural'skiy filial AN SSSR (Ural Branch of the AS USSR)

AVAILABLE: Library of Congress.

Card 3/3

1. Steel-Transformations
2. Austenitic steel-Deformation



AUTHORS: Gorbach, V. G. and Sadovskiy, V. D. SOV/126-6-1-13/33

TITLE: Influence of the Speed of Heating on the Manifestation of the "Heredity" of the Austenitic Structure in Preliminarily Hardened Chromium Steels (Vliyaniye skorosti nagreva na proyavleniye nasledstvennosti struktury austenita v predvaritel'no zakalennykh khromistykh stalyakh)

PERIODICAL: Fizika Metallov i Metallovedeniye, 1958, Vol 6, Nr 1, pp 106-109 + 2 plates (USSR)

ABSTRACT: The results are described of metallographic investigation of the influence of the speed of heating and the Cr content on the extent to which the after effects of preliminary over-heating manifest themselves in the structure of steel. The aim of the work was to elucidate the changes in the conditions of re-establishment of the grain for steels alloyed with various quantities of Cr (3.47, 6.22, 12.22%). For the investigations three chromium steels were chosen, the chemical compositions of which are entered in a Table, p 107. The blanks were first hardened from 1300°C and then tempered at Card 1/3 650°C and sliced into cubes of 10 x 10 x 8 mm; for

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Influence of the Speed of Heating on the Manifestation of the  
'Heredity' of the Austenitic Structure in Preliminarily Hardened  
Chromium Steels

experiments involving rapid heating, the hardened blanks were cut into plates 1.5, 3, 6 mm thick and 10 x 10 mm cross section. Heating with a speed of 0.25 to 135°C/min was effected in an ordinary laboratory furnace, whilst heating with speeds of 135 to 1000°C/min was effected in a salt bath. After preliminary treatment the specimens were heated under the above mentioned temperature conditions until the austenitic state was reached and, following that, they were soaked for a certain time in a bath of 650°C for the purpose of partial troostite formation; this treatment was followed by hardening in water and subsequent metallographic analysis. It was found that the structure of the austenite forming during heating of preliminarily hardened steel depends to a great extent on the speed of heating. In the case of rapid heating of hardened, non-tempered steel, the initial austenite grain becomes re-established whereby the speed of heating necessary for re-establishment of

Card 2/3 the grain will be the lower the higher the chromium

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Influence of the Speed of Heating on the Manifestation of the  
"Heredity" of the Austenitic Structure in Preliminarily Hardened  
Chromium Steels

content of the steel. In the case of slow heating of  
hardened and tempered steel a re-establishment of the  
initial grain is also observed, whereby the speed of  
heating necessary for re-establishing the grain will be  
the lower the higher the chromium content of the steel.  
There are 5 figures, 1 table and 9 references, all of  
which are Soviet.

ASSOCIATION: Institut fiziki metallov Ural'skogo filiala AN SSSR  
(Institute of Metal Physics, Ural Branch of the Ac.Sc.,  
USSR)

SUBMITTED: July 31, 1957

Card 3/3

1. Chromium steel---Heat treatment    2. Chromium steel---  
Phase studies    3. Austenite---Properties    4. Chromium---  
Metallurgical effects

AUTHORS: Sokolov, B. K. and Sadovskiy, V. D. SOV/126-6-3-27/32

TITLE: On the Formation of Austenite During Heating of Steel  
by Reverse Martensitic Transformation (Otnositel'no  
obrazovaniya austenita pri nagreve staley putem  
obratnogo martensitnogo prevrashcheniya)

PERIODICAL: Fizika Metallov i Metallovedeniye, 1958, Vol 6, Nr 3,  
pp 568-569 (USSR)

ABSTRACT: In an earlier paper (Ref 1) metallographic proof is  
given on the possibility of two mechanisms of the  
formation of austenite during heating of hardened engineer-  
ing alloy steel. In the same way, as during decomposition  
of super-cooled austenite, a diffusion mechanism of phase  
recrystallisation (pearlite-troostite decomposition) and  
diffusionless martensite transformation are possible.  
Austenite formation can also be brought about by diffusion  
interaction of ferrite and carbides or by a non-diffusion  
process similar to the reversible martensite transforma-  
tion. However, the proofs given in the earlier work  
(Ref.1) of the existence of a non-diffusional formation of  
austenite in steel are not exhaustive. Direct observation  
Card 1/4 of the non-diffusional formation of austenite can be

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On the Formation of Austenite During Heating of Steel by Reverse Martensitic Transformation

effected by a vacuum metallography method described by M. G. Lozinskiy (Ref 2). The non-diffusional transformation of the martensitic type, which is associated with maintenance of coherence during the growth of the new phase is always accompanied by the formation of a relief on the polished surface of the specimen (Ref 3). This is due to the fact that during such a transformation the atoms can shift only in certain directions relative to their neighbours. As a result of such insignificant individual shifts of the atoms large collective displacement of a macroscopic order will result. The latter lead to the formation of a relief on the polished surface. Thus, in the case of martensitic transformation a clear "acicular" relief will occur. T. Ko and S. A. Cottrell (Ref 4) observed the formation of a relief during bainite transformation and this led to the assumption that the formation of bainite is also based on non-diffusional transformation. The occurrence on the polished specimen surface of a relief during heating should indicate that the formation of the austenite is

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On the Formation of Austenite During Heating of Steel by Reverse Martensitic Transformation

according to the non-diffusional mechanism. For obtaining a structure of coarse acicular martensite, steel 40KhGS was quenched from 1300°C and from this steel specimens 10 x 4 x 55 mm were produced, which were heated in a vacuum metallography device (Ref 2) at a rate of 50°C/sec. At temperatures of the order of 700°C a relief appeared on the surface, a photo of which is reproduced in Fig.1. The formation of this relief proceeded at a high speed and almost simultaneously on a number of grains. The relief had an acicular character which indicates that the formation of austenite under these conditions is by the non-diffusional process similar to the reversible martensitic transformation. In specimens tempered prior to heating (at 600°C for two hours) no relief was obtained under equal conditions. Obviously, the diffusion mechanism of austenite formation is caused by the preliminary tempering of the steel

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SOV/126-6-3-27/32  
On the Formation of Austenite During Heating of Steel by Reverse  
Martensitic Transformation

prior to heating.

There are 1 figure and 4 references, 3 of which are  
Soviet, 1 English.

(Note: This is a complete translation)

ASSOCIATION: Institut fiziki metallov Ural'skogo filiala AN SSSR  
(Institute of Metal Physics, Ural Branch of the Ac.Sc.,  
USSR)

SUBMITTED: January 29, 1958

1. Steel--Phase studies    2. Austenite--Develppment    3. Diffusion  
--Applications    4. Martensite--Transformations

Card 4/4

SOV/126-6-4-14/34

AUTHORS: Gorbach, V.G.,  
Sadovskiy, V.D.

TITLE: The Effect of Preliminary Heat Treatment on the Kinetics  
of Decomposition of Pearlitic Troostite in Supercooled  
Austenite (Vliyaniye predvaritel'noy termicheskoy  
obrabotki na kinetiku perlito-troostitnogo raspada  
pereokhlazhdennogo austenita)

PERIODICAL: Fizika Metallov i Metallovedeniye, 1958, Vol 6,  
Nr 4, pp 665-672 (USSR)

ABSTRACT: It has been shown by other workers (Ref.1-6) that the  
structure and constitution of austenite formed at  
temperatures above the critical points depend on  
(i) the initial structure of the steel as determined by  
its previous thermal history and (ii) the rate at which  
it is heated to the austenitic temperature range. The  
object of the present investigation was to study (by  
means of magnetometric measurements and microscopic  
analysis) the effect of these two factors on the kinetics  
of transformation of supercooled austenite in three

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SOV/126-6-4-14/34

The Effect of Preliminary Heat Treatment on the Kinetics of Decomposition of Pearlitic Troostite in Supercooled Austenite

chromium steels (3, 6 and 12% Cr) whose complete chemical analysis is given in Table 1. In the first series of experiments, specimens of the investigated steels quenched from the austenitic range were re-heated to a temperature above  $A_3$ , and the effect of the rate of heating on the extent to which the initial structure was preserved after the secondary heating was examined. It was found that the original grains were fully preserved both after very slow and very rapid heating. The precise values of these critical rates of heating depended on the composition of steel: At "slow" rates of heating, i.e. when formation of austenite was associated with diffusion processes, the original grains of the 3, 6 and 12% Cr steels were fully preserved if the rate of secondary heating did not exceed 2, 1 and  $0.25^\circ\text{C}/\text{min}$  respectively. At "very fast" rates of heating, i.e. when practically no diffusion took place, full preservation of the original grains was ensured if the respective rates of heating were not lower than

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The Effect of Preliminary Heat Treatment on the Kinetics of Decomposition of Pearlitic Troostite in Supercooled Austenite

1000, 260 and 4°C/min. At the intermediate rates of heating (referred to later as "fast") the original grains were not preserved in the material heated to the austenitic range. In the next stage, the combined effect of (a) the preliminary treatment (determining the initial structure of steel) and (b) the rate of secondary heating (determining the degree of preservation of the initial structure after heating to the austenitic range) on the kinetics of decomposition of austenite were studied on specimens of the investigated materials subjected to one of the following thermal treatments: 1. (a) Annealing. (b) "Slow" reheating to the austenitic range (~950°C). 2. (a) Quenching of the overheated material from 1300°C and tempering at 650°C. (b) Slow reheating to the austenitic range. 3. (a) As in No.2. (b) "Fast" reheating to the austenitic range. 4. (a) No overheating. Quenching from the normal (~950°C) temperature and tempering at 650°C. (b) "Slow" reheating to the

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The Effect of Preliminary Heat Treatment on the Kinetics of Decomposition of Pearlitic Troostite in Supercooled Austenite

austenitic range. 5.(a) Quenching of the overheated material from 1300°C. (b) "Very fast" reheating to the austenitic range. 6(a) No overheating. Quenching from the normal temperature. (b) As in No.5. Some of the typical results are reproduced graphically. The "TTT" curves of the 6% Cr steel subjected to thermal treatments No.2, 3, 4 and 1 are shown in Fig.1a, b, B and 2 respectively. Fig.2a and b shows the primary pearlitic troostite formed in the 12% Cr steel subjected to thermal treatments No.2 and 3. Fig.3 shows the rate of decomposition of supercooled austenite tempered at 650°C; in the 12% Cr steel (i) overheated, quenched from 1300°C, tempered at 650°C and then reheated to the austenitic range at the "slow" (0.25°C/min), "fast" (2°C/min) and "very fast" (8, 35 and 135°C/min) rates of heating (curves a, b, B, 2 and 3) and (ii) quenched from the normal temperature, tempered at 650°C and reheated at 0.25°C/min (curve e) and 135°C/min (curve X). The "TTT" curves of the 6% Cr

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The Effect of Preliminary Heat Treatment on the Kinetics of Decomposition of Pearlitic Troostite in Supercooled Austenite

steel subjected to treatments No.5 and 6 are shown in Fig.4a,b. Finally, curves a and b in Fig.5 show the rate of decomposition of supercooled austenite tempered at 650°C in the 12% Cr steel quenched from 1300°C (overheated), and then reheated at "slow" and "very fast" rates of heating. The corresponding decomposition rates of austenite in specimens that had not been overheated during the preliminary treatment are represented by curves B and 2. The experimental results confirmed that certain features of the structure of a steel specimen can be preserved on heating to the austenitic range if either very slow or very fast rates of heating are employed, although it is not known why this should happen when steel is heated under such conditions that formation of austenite is associated with diffusion phenomena. It was shown also that when excessive grain growth due to overheating occurs during the preliminary treatment and when - as a result of very slow or very fast rate of heating - the large grains so

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OV/126-6-4-18/3"

The Effect of Preliminary Heat Treatment on the Kinetics of Decomposition of Pearlitic Troostite in Supercooled Austenite

formed are preserved after secondary heating, the rate of decomposition of supercooled austenite is considerably reduced. This is true for transformations occurring at temperatures near the  $A_1$  critical point: The rate of transformation in the intermediate temperature range (as can be seen from various "TTT" curves) was not affected by variation of the rate of heating during the secondary treatment, whatever the thermal history and the initial structure of the investigated specimens. Similarly, in no case was the rate of decomposition of supercooled austenite significantly affected by the rate of heating employed during the secondary treatment, if no excessive grain

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SOV/126-6-4-14/34

The Effect of Preliminary Heat Treatment on the Kinetics of  
Decomposition of Pearlitic Troostite in Supercooled Austenite

growth had occurred in the steel specimen during the  
preliminary heat treatment (curves e and X Fig.3).  
There are 5 figures and 12 Soviet references.

ASSOCIATION: Institut Fiziki Metallov Ural'skogo Filiala AN SSSR  
(Institute of Physics of Metals, Ural Branch of the  
Ac.Sc. USSR)

SUBMITTED: 31st July 1957.

Card 7/7

SOV/126-6-5-41/43

AUTHORS: Sadovskiy, V. D., and Sokolkov, Ye. N.

TITLE: Appearance of Brittleness in the Decomposition of a Solid Solution of Mn and Si Based on Copper (Yavleniye khrupkosti pri raspade tverdogo rastvora Mn i Si na osnove medi)

PERIODICAL: Fizika Metallov i Metallovedeniye, 1958, Vol 6, Nr 5, pp 954-955 (USSR)

ABSTRACT: The process of decomposition of a copper based solid solution with 1.5% Mn and 3.5% Si (manganese-silicon bronze) and its relationship with plastic properties were studied. In the decomposition of this solid solution a second phase separates out (Refs 1,2). This second phase is  $Mn_2Si$  and it is assumed that it does not affect the plastic properties of the bronze (Ref 3). The present paper deals with further studies of this process and its effect on plastic properties. The bronze was hardened at  $800^{\circ}C$ . Such a treatment ensures complete dissolution of  $Mn_2Si$  and subsequent rapid cooling on quenching produces a saturated solid solution at room temperature. A series of samples subjected to the above

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Appearance of Brittleness in the Decomposition of a Solid  
Solution of Mn and Si Based on Copper

treatment was tempered at temperatures of 200-750°C in steps of 50°C. The duration of tempering was three hours and the samples were subsequently quenched in water. Microstructure studies of the samples showed that in the hardened state the alloy is homogeneous and it consists of uniform grains of the  $\alpha$ -phase (Fig 1). As the temperature of the subsequent tempering is increased, the second phase separates out in the alloy starting from 350°C tempering. The amount of Mn<sub>2</sub>Si separating out is greatest in samples tempered at 500-600°C (Fig 2). Impact tests were carried out on samples of 10 x 10 x 60 mm dimensions with notches 2 mm wide and 2 mm deep. The results showed no dependence of the impact strength on the degree of decomposition of the alloy. A second series of samples, which had undergone the treatment described above (hardening and tempering), were further subjected to cold plastic deformation by rolling at the rate of 1.5 m/min. The reduction in size during rolling was 30%. The initial size of the samples was chosen to make the Card2/4 final dimensions the same as for the first series, i.e.



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Solution of Mn and Si Based on Copper

10 x 10 x 60 mm. Fig.3 shows the results of tests of samples subjected to cold plastic deformation. The ordinate represents impact strength and the abscissa represents the tempering temperature. This time the plastic properties are obviously affected by the decomposition of the alloy and the minimum of impact strength occurs at those tempering temperatures (500-600°C) which produced the largest amounts of the second phase in the alloy. Impact strength decreases from 19 kg.m/cm<sup>2</sup> for cold-rolled samples which were previously tempered at 250°C to 5.5 kg.m/cm<sup>2</sup> for cold-rolled samples tempered at about 600°C. These results are in agree with the data obtained from the microstructure. The observed behaviour is due to lowering of the degree of plasticity of the alloy by previous plastic deformation; such a lowering of plasticity makes it possible for the second phase (Mn<sub>2</sub>Si) to produce the expected embrittlement of the alloy. Plastic deformation of a 2-phase alloy produces also high internal stresses which are higher than the stresses in the corresponding alloy consisting of a single phase.

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SOV/126-6-5-41/43  
Appearance of Brittleness in the Decomposition of a Solid  
Solution of Mn and Si Based on Copper

There are 3 figures and 3 references, 2 of which are  
Soviet, 1 English.

ASSOCIATION: Institut fiziki metallov Ural'skogo filiala AN SSSR  
(Institute of Metal Physics, Ural Branch of the Ac.Sc.,  
USSR)

SUBMITTED: November 5, 1967

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SOV/137-59-4-8505

Translation from: Referativnyy zhurnal, Metallurgiya, 1959, Nr 4, p 166 (USSR)

AUTHOR: Sadovskiy, V.D.

TITLE: The Structural Mechanism of Phase Recrystallization in Heating of Steel

PERIODICAL: Tr. In-ta fiz. metallov. Ural'skiv fil. AS USSR. 1958, Nr 20, pp 303-310

ABSTRACT: The author presents a review on the investigation of changes in grain dimensions after phase recrystallization of steel, by observing the changes in the shape of breaks and metallographic structure. He submits main scientific results of work carried out in this field, obtained in the laboratory of metallography of the Institute of Physics UFAN USSR. There are 29 bibliographical titles.

A.T.

Card 1/1

69359  
SOV/123-59-19-78745

Translation from: Referativnyy zhurnal. Mashinostroyeniye, 1959, Nr 19, p 127 (USSR)

18.7100  
AUTHORS:

Gorbach, V.G., Sadovskiy, V.D.

TITLE:

The Effect of Preliminary Heat Treatment of Steel on the Kinetics of Supercooled Austenite Transformation

PERIODICAL:

Tr. In-ta fiz. metallov. Ural'skiy fil. AS USSR, 1958, Nr 20, pp 311-327

ABSTRACT:

The authors investigated the decomposition kinetics of supercooled austenite in steels of the grades 30Kh3, 40Kh6, 40Kh2, 37KhNZ, and 38KhGN, which were preliminary hardened at a temperature of 1,300°C. The possibility was confirmed to regenerate the grains of austenite, corresponding to the initial superheating, in the course of a very slow or a very quick heating for the secondary hardening. Austenite which is formed by the non-diffusion way (quick heating), recrystallizes at lower temperatures than austenite formed by diffusion (slow heating). When regenerating the large-sized austenite grains both by the non-diffusion and by the diffusion method, a retardation of the pearlitic-troostitic decomposition of austenite can be observed, which is connected with the boundary character of the origin

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69359

SOV/123-59-19-76745

The Effect of Preliminary Heat Treatment of Steel on the Kinetics of Supercooled Austenite Transformation

of decomposition products. The size of the austenite grains being equal, austenite of the non-diffusion process leads to a lesser degree of the retardation of decomposition, which is explained by the fact that it retains the structural defects in the form of lattice deformations and others. 9 figures, 11 references.

S.A.G.

✓

Card 2/2

SOV/137-59-5-11397

Translation from: Referativnyy zhurnal, Metallurgiya, 1959, Nr 5, p 273  
(USSR)

AUTHORS: Kompaneytsev, N.A., Sadovskiy, V.D.

TITLE: Correcting the Structure and Fracture of Cast Alloyed Steel by Heat Treatment

PERIODICAL: Tr. In-ta fiz. metallov. Ural'skiy fil. AS USSR, 1958, Nr 20, pp 329 - 338

ABSTRACT: The author establishes the presence of a particular critical temperature in the austenite range at which recrystallization of austenite, hard-faced during the  $\alpha \rightarrow \gamma$  transition, takes place. The secondary intergranular texture, determining the structural heredity of the coarse grains of cast steel, is fully destroyed at this temperature. The heating conditions as a means to prevent hereditary coarse grains of textural character depend on the initial structure of cast steel. In the case of ferrite-perlite or perlite-troostite structures, single-stage heating above the critical points is sufficient to correct the structure and fracture.

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SOV/137-59-3-6413

Translation from: Referativnyy zhurnal. Metallurgiya, 1959, Nr 3, p 211 USSR)

AUTHORS: Sadoyskiy, V. D., Sokolov, B. K.

TITLE: The Effect of Phosphorus Content on the Notch Toughness of Cr-Ni and Cr-Ni-Mo Steels (Vliyaniye soderzhaniya fosfora na udarnuyu vyazkost' khromonikelevykh i khromonikel' molibdenovykh staley)

PERIODICAL: Tr. Ural'skogo politekhn. in-ta, 1958, Nr 68, pp 45-53

ABSTRACT: The effect of P content on the  $a_k$  values of two types of steel was investigated after quenching and tempering at various temperatures. The composition of the steel was as follows: 1) 0.25-0.27% C, 0.26-0.32% Si, 0.40-0.51% Mn, 2.91-3.1% Cr, 1.00-1.06% Ni, and 0.024-0.110% P; 2) 0.27-0.28% C, 0.21-0.33% Si, 0.39-0.43% Mn, 2.95-3.06% Cr, 0.98-1.04% Ni, 0.35-0.42% Mo, and 0.022-0.160% P. It was established that as the P content of these steels is increased, an over-all reduction in the value of  $a_k$  is observed after tempering at temperatures ranging from 20 to 675°C; this is accompanied by an increase in the susceptibility to temper brittleness (TB) and a reduction in the value of  $a_k$  during additional low tempering after refining anneal. The adverse influence of P on the  $a_k$  value is

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The Effect of Phosphorus Content on the Notch Toughness of Cr-Ni (cont.)

attributable to the fact that P aggravates the susceptibility of the steels to reverse TB and, as its concentration is increased, extends the temperature range of TB down to room temperature. Bibliography: 8 references.

I. B.

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S/137/60/000/009/015/029  
A006/A001

Translation from: Referativnyy zhurnal, Metallurgiya, 1960, No. 9, p. 250,  
# 21524

AUTHORS: Sokolov, Ye.N., Sadovskiy, V.D., Petrova, S.N.

TITLE: Structure of Austenitic Grain Boundaries and Temper Brittleness of Structural Steels

PERIODICAL: V sb.: Nekotoryye probl. prochnosti tverdogo tela. Moscow-Lenin-grad, AN SSSR, 1959, pp. 165-171

TEXT: The authors investigated the mechanism of the effect of heat and mechanical treatment on the weakening of temper brittleness of structural alloys: 20XH3 (20KhNZ), 35XГCА (35KhGSA), 35XH410 (35KhN4Yu) and 30XH8C (30KhN8S) steels. It is established that the weakening of the temper brittleness of structural alloyed steels during the thermomechanical treatment is connected with higher values of brittle strength. Plastic deformation in austenitic state under conditions preventing the development of recrystallization of hardfaced austenite

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SOV/126-7-1-14/28

AUTHORS: Malyshev, K.A., Bogacheva, G.N., Sadovskiy, V.D. and  
Ustyugov, P.A.

TITLE: Influence of the Temperature of Plastic Deformation on the  
Structure and Impact Strength of Austenitic Steel  
(Vliyaniye temperatury plasticheskoy deformatsii na  
strukturu i udarnuyu vyazkost' austenitnoy stali)

PERIODICAL: Fizika Metallov i Metallovedeniye, 1959, Vol 7, Nr 1,  
pp 102-109 (USSR)

ABSTRACT: In this paper the structure of austenitic steel, deformed  
by rolling at various temperatures, was investigated, and  
it was endeavoured to establish a relationship between the  
change in structure and mechanical properties in the  
ductile and brittle states (the last after ageing).  
Experiments were carried out with the austenitic steel  
60Kh4G8N8V. Specimens of this steel, 11 x 11 x 60 mm,  
were deformed in laboratory hand-rollers at various  
temperatures between room temperature and 1200°C (at  
50° intervals). Reduction in area in all cases was  
Card 1/6 about 30%. Rolling speed was 13 mm/sec in all cases.

SOV/126-7-1-14/28

Influence of the Temperature of Plastic Deformation on the Structure and Impact Strength of Austenitic Steel

Prior to deformation, all specimens were heated to 1150° and held there for 20 minutes. Deformation at temperatures below 500°C was carried out on specimens which had been quenched from 1150°C. For deformation at higher temperatures specimens, which had been heated to 1150°C, were cooled to the required temperatures. In order to avoid recrystallization the specimens were cooled in water immediately after deformation. In order to bring out slip lines the deformed specimens, prior to being made into micro-sections, were aged at 700°C for two hours. A notch, 2mm deep, was made in the deformed specimens for impact testing. As the toughness of austenitic steel, cooled in water after deformation, is very great, impact tests were carried out at liquid nitrogen temperatures. Under certain conditions the investigated austenitic steel suffers very intense ageing which greatly lowers its impact strength. The influence of the preliminary plastic deformation of austenite on the impact resistance of the steel under conditions of prolonged ageing was studied by testing the impact resistance of deformed specimens which had been aged for a long time. The impact

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Influence of the Temperature of Plastic Deformation on the Structure and Impact Strength of Austenitic Steel

test in this case was carried out at room temperature. Fig. 1 shows the influence of the temperature of deformation on the structure of austenite; (a) deformation at 20°C; (6) at 150°C; (g) at 300°C; (z) at 500°C. In Fig. 2 the influence of deformation temperature on the structure of austenite is again shown: (a) deformation at 700°C; (6) at 850°C; (g) at 1050°C; (z) at 1200°C. Fig. 3 shows the appearance of grain boundaries after high temperature deformation. Fig. 4 shows the structure of the specimen deformed at room temperature after partial recrystallisation. Fig. 5 shows the structure of a specimen deformed at 450°C after partial recrystallisation. Fig. 6 shows the structure of a specimen deformed at 850°C after partial recrystallisation. In Figs. 7 and 8 the results of hardness and impact strength tests of austenitic steel specimens deformed by 30% by rolling at temperatures of 20, 400, 500, 900, 1000 and 1100°C, and water cooled, are shown. The deformed specimens were tested at liquid nitrogen temperature (Fig. 7) and at room temperature (Fig. 8). The results of impact strength and hardness determinations of deformed and un-deformed

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Influence of the Temperature of Plastic Deformation on the Structure  
and Impact Strength of Austenitic Steel

ASSOCIATION: Institut fiziki metallov AN SSSR (Institute of Metal  
Physics, Ac.Sc. USSR); Ural'skiy zavod tyazhelogo  
mashinostroyeniya imeni S. Ordzhonikidze (Ural Establish-  
ment of Heavy Machine-building imeni S. Ordzhonikidze).

SUBMITTED: November 19, 1957

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Influence of the Temperature of Plastic Deformation on the Structure and Impact Strength of Austenitic Steel

specimens are shown in Fig.9. The change in structure of austenite with rise in deformation temperature is on the whole analogous to results obtained for polycrystalline pure aluminium (Refs.1-5), and permits a conclusion about the mechanism of plastic deformation to be drawn. At low temperatures deformation occurs by slip. As the temperature rises this is replaced by block formation. The absence of slip lines within the grains of austenite deformed at high temperatures, and the fact that recrystallisation develops along the grain boundaries, is a proof that deformation becomes increasingly localised in the grain boundaries as the temperature rises. The present investigation has been carried out under conditions of great deformation speed and large reductions, i.e. under conditions approaching those of hot rolling. The results obtained lead to the conclusion that the mechanism of block formation and diffusion plasticity observed at high temperatures is not an exceptional characteristic of metal creep under load, but is the basis

Card 4/6 for the actual process of mechanical deformation of metals

SOV/126-7-1-14/28

Influence of the Temperature of Plastic Deformation on the Structure and Impact Strength of Austenitic Steel

at high temperatures. Hence it can be assumed that raising the temperature exercises a stronger influence on the change of the mechanism of plastic deformation than change in deformation speed. The mechanical properties of austenite deformed at various temperatures without relaxation and recrystallisation can be related to the structure and mechanism of mechanical deformation. Deformation of austenite at 400-450°C gives a more favourable combination between impact strength and hardness than cold deformation. The experiment has shown that working of austenite in the temperature range 900-1100°C leads to a distinct decrease in brittleness of the austenitic steel which is normally caused by lengthy ageing. This decrease in brittleness may be associated with the mechanism of plastic deformation (block formation) and the jagged shape of the boundaries of deformed grains which lengthens the intergranular boundaries and renders intergranular fracture more difficult. There are 9 figures and 8 references, of which 3 are English

Card 5/6 and 5 Soviet.

SADOVSKIY, V.D., prof., doktor tekhn.nauk, red.; GULYAYEV, A.P., prof., doktor tekhn. nauk, retsenzent; DUGINA, N.A., tekhn. red.

[Metals and their heat treatment] Problemy metallovedeniia i termicheskoi obrabotki. Moskva, Gos. nauchno-tekhn. izd-vo mashinostroit. lit-ry. No.2. 1960. 166 p. (MIRA 14:8)  
(Metals—Heat treatment)



S/126/60/009/01/005/031  
E111/E191

AUTHORS: Varskaya, A.K., Kompaneytsev, N.A., Sokolov, B.K.,  
and Sadovskiy, V.D.

TITLE: X-Ray Investigation of Phase Recrystallization during  
Heating of Steel

PERIODICAL: Fizika metallov i metallovedeniye, 1960, Vol 9, Nr 1,  
pp 28-30 (USSR)

ABSTRACT: It has been reported (Refs 1, 2) that metallographic investigation of phase recrystallization during heating of some structural alloy steels, which have in their initial state a crystallographically ordered structure of martensite or bainite, showed that heating rates influence austenite structure formed above  $A_{c3}$ . The object of the present investigation was to check this effect by X-ray diffraction and also the reported (Ref 3) existence of intragranular texture in the austenite at intermediate heating rates. An axial camera with unfiltered iron radiation was used, with a special holder to ensure that the same spot was photographed before and after the selected heat treatment. Commercial steels type 40KhS, 35KhGS and 37KhN3A previously hardened from 1300 °C were used; parallel

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S/126/60/009/01/005/031

E111/E191

X-Ray Investigation of Phase Recrystallization during Heating of Steel

tests were made on the same steels in the cast state (hardened immediately after solidification). Slow-heating was effected in vacuum. With slow-heating directly above  $A_{c3}$  all the original texture maxima are reproduced in the X-ray diagrams (Fig 1 a-6), but new orientation appears if the heating is at 50-80 °C and more above  $A_{c3}$ . Very rapid heating of untempered steel similarly restores (above  $A_{c3}$ ) the original grain with slightly redistributed orientations (Fig 2 a-6) and the texture disappears if the temperature is high enough for austenite recrystallization. With intermediate heating rates the austenite grains obtained above  $A_{c3}$  are generally considerably finer than originally and have a different and weaker texture (Fig 3 a-6), the same effect being obtained with very rapid heating of tempered specimens. At temperatures of 1100 °C and over texture disappears. This work was reported at the VI Vsesoyuznoye nauchno-tekhnicheskoye soveshchaniye po primeneniyu rentgenovskikh luchey k issledovaniyu materialov (All-Union Scientific-Technical Conference on

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S/126/60/009/01/005/031  
E111/E191

X-Ray Investigation of Phase Recrystallization during Heating of  
Steel  
the Use of X-rays for Materials Testing), June 24, 1958.  
There are 3 figures and 5 Soviet references.

ASSOCIATION: Institut fiziki metallov AN SSSR  
(Institute of Physics of Metals, Acad.Sci. USSR) ✓

SUBMITTED. July 25, 1959

Card 3/3

S/126/60/009/03/026/033  
E111/E452

AUTHORS: Sadovskiy, V.D. and Sokolov, B.K.

TITLE: On the Possibility of Diffusionless Formation of Austenite During the Heating of Steel ✓

PERIODICAL: Fizika metallov i metallovedeniye, 1960, Vol 9, Nr 3, pp 463-465 (USSR)

ABSTRACT: The authors reply to criticism by V.N.L'nyanoy and I.V.Salli (pp 461-463 of this issue) of their contention that diffusionless formation of austenite can occur during rapid heating of hardened steel. They state that the disappearance of relief in the reverse transformation, considered a necessary consequence of the diffusionless reverse transformation by L'nyanoy and Salli, does not apply to the normal reverse transformation associated with temperature hysteresis. They give photomicrographs of the same specimen of nickel (27.8%) iron after direct (Fig 1a) and reverse (Fig 1b) martensite transformation, where the diffusionless mechanism is established (Ref 2,3). The relief found to appear at relatively slow (200°C per minute) heating rates the authors attribute to volume ✓

Card 1/2


S/126/60/009/03/026/033  
E111/E452

On the Possibility of Diffusionless Formation of Austenite During  
the Heating of Steel

changes accompanying tempering of martensite. They  
consider the main evidence in favour of the  
diffusionless mechanism the restoration of the original  
austenite grain (Ref 4 and 5). There are 1 figure and  
6 references, 5 of which are Soviet and 1 English.

ASSOCIATION: Institut fiziki metallov AN SSSR  
(Institute of Physics of Metals AS USSR)

Card 2/2



SADOVSKIY, V.D.

81908  
5/136/60/010/01/013/019  
E111/E335  
Influence of Deformation of Martensite on the Cold Shortness of Austenitic Steels and Their Hardening in Plastic Deformation  
0-0-0-71 V. 0-0-0-10 S. 0-0-0-67 P. 60 mm long pieces were cut from 13 x 13 mm forged bars. The pieces were heated to 1150°C and cooled in water. Metallographic tests showed no martensite transformation on cooling to -196°C. Standard notched test-pieces (2 mm deep notch to 10 mm radius of curvature) were used for impact (deformation martensite) tests at various temperatures. Alpha-phase measuring magnetic susceptibility (Ref. 3) of austenite on 5 x 4 x 9 mm pieces cut from the fracture region of impact specimens, Kohr's salt being used as the standard. In a second series of experiments the austenitic steel standard. Pigs. 1-3 show the toughness of the various steels as functions of test temperature. The effect of the various alloying elements being brought out; magnetic susceptibility as functions of test temperature being similarly shown in Figs. 4 and 5. Pigs. 6 and 7 show deformation of martensite structures and Fig. 8 the fracture deformation of martensite structures and Fig. 8 the Card 2/4

81908  
5/136/60/010/01/013/019  
E111/E335  
Influence of Deformation of Martensite on the Cold Shortness of Austenitic Steels and Their Hardening in Plastic Deformation  
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8308  
5/126/60/010/01/013/019  
8111/8133

Influence of Deformation of Martensite on the Cold Shortness of Austenitic Steels and Their Hardening in Plastic Deformation

tensile strength, yield point, toughness and magnetic susceptibility on deformation. Temperature is shown in Figs. 9, 10, 11 and 12. 90018 and 50018 steels are predominantly hardened by cold shortness, which could be considerably reduced by additional alloying with chromium and nickel. The reason for the cold shortness is deformation-martensite formation during low-temperature impact testing. The good effect of alloying by the manganese steels with chromium and nickel is explained by the increased martensite stability with respect to plastic deformation induced martensite transformation. Formation of such martensite is the reason for the greater hardening of manganese austenitic steels in cold compared with 200-300 °C plastic deformation. In stable austenitic steels, additionally alloyed with chromium and nickel, hardening in cold and seal-hot work-hardening is practically the same. There are 12 figures, 3 tables and 5 Soviet references.

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8108

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8111/8133

Influence of Deformation of Martensite on the Cold Shortness of Austenitic Steels and Their Hardening in Plastic Deformation

ASSOCIATION: Institut fiziki metallov AN SSSR (Institute of Physics of Metals of the A.S.S.R. USSR)

Ural'skiy zavod lyazhologo mashinostroyeniya im.

S. Ordzhonikidze (Ural Heavy Engineering Works)

Leonid S. Ordzhonikidze

SUBMITTED: February 23, 1960

Card 4/4

SADOVSKIY, V.D.; BOGACHEVA, G.N.; SMIRNOV, L.V.; SOROKIN, I.P.; KOMPANEYTSYEV,  
N.A.

Investigating phase recrystallization in titanium. Fiz. met. i  
metalloved. 10 no.3:397-403 S '60. (MIRA 13:10)

1. Institut fiziki metallov AN SSSR.  
(Titanium--Metallography)  
(Phase rule and equilibrium)



POPOV, Aleksandr Artem'yevich; POPOVA, Lyudmila Yevgen'yevna; SADOVSKIY, V.D., doktor tekhn. nauk, prof., retsenzent; YERMAKOV, N.P., tekhn. red.

[Heat treatment handbook; isothermal and thermokinetic diagrams on the decomposition of undercooled austenite] Spravochnik termista; izotermicheskie termokineticheskie diagrammy raspada pereokhlazhdennogo austenita. Moskva, Mashgiz, 1961. 430 p.

(MIRA 15:2)

(Steel--Heat treatment) (Austenite)

S/129/61/000/001/010/013  
E111/E152

AUTHOR: Sadovskiy, V.D., Doctor of Technical Sciences,  
Professor

TITLE: Block Structure and Recrystallization of Austenite  
in High Speed Steel

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov,  
1961, No. 1, pp. 48-57

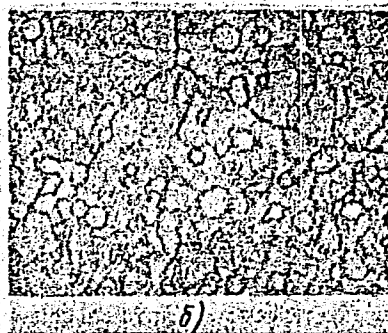
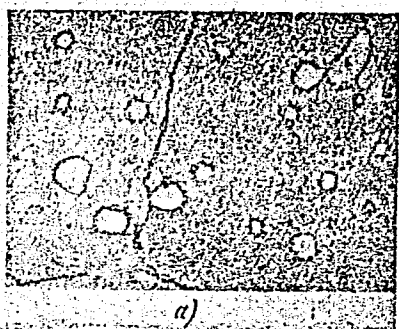
TEXT: The present article is based on two previous  
publications of the present author and others (Refs 8, 9) and new  
investigations at the Institut Fiziki metallov AN SSSR (Institute  
of Physics of Metals, AS USSR) by S.N. Petrova and  
V.M. Schastlivtsev. The experimental work consisted in micro-  
structural observations on specimens of high-speed steel  
subjected to various heat treatments and mechanical working.  
Fig.1 shows microstructure after double hardening from 1280 °C  
without and with intermediate tempering.

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E111/E152

Block Structure and Recrystallization of Austenite in High Speed Steel

Fig.1



Figs 2 and 3 show areas with partial recrystallization of austenite (the latter with rapid heating).

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E111/E152

Block Structure and Recrystallization of Austenite in High Speed Steel

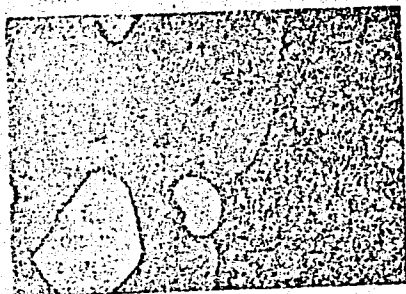
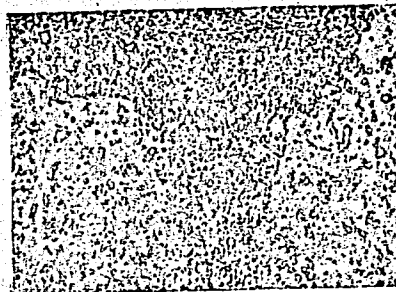


Fig. 2

The microstructures after hardening from 1280 °C of an initially pearlitic structure are shown in Fig.4, while Fig.5 shows the structure of annealed steel in the initial, the hardened and the tempered and subsequently hardened states.

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Фиг. 3. Микроструктура участка с частичной рекристаллизацией аустенита. Быстрый нагрев закаленной стали. X80.